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Critical review of life cycle assessments conducted on aquaculture systems: identification of environmental improvements

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Answering the growing demand of food for human consumption, the aquaculture industry has grown considerably for the past decades and is expected to expand further in the future. It is thus critical to ensure that the development of this sector is associated with as low environmental impacts as possible. Even though it is often presented as the most environmentally sustainable source of proteins, seafood farming is associated with multiple environmental impacts such as climate change, eutrophication or biodiversity loss. A widely used tool to assess environmental sustainability of food products is life cycle assessment (LCA), and it has been applied to aquaculture systems in multiple studies over the last 15 years. What can we learn from this pool of LCA studies that will help system developers and decision makers reduce the impacts from the aquaculture sector? Which general trends can be identified to enable drawing recommendations about preferable system characteristics? To answer these questions, we performed a critical review of 65 LCA studies of aquaculture systems. We used meta-level statistical analysis to compare their findings and conclusions with respect to the different types of aquaculture systems. We found that the type of technology used is highly influential on the environmental impacts, and that recirculating aquaculture systems tend to have lower eutrophication impacts than other technologies but higher impacts for other categories of impact. High-intensity systems tend to be associated with high global impacts but lower regional and local impacts, even though some modern and highly optimized systems stand out with low impacts in all impact categories. Generally, polyculture, in particular integrated multi-trophic aquaculture, seems to have lower environmental impacts than monoculture. The choice of aquafeed was also found to be extremely important, as it usually drives the majority of environmental impacts except eutrophication. It should be noted that certain management practices that might impact negatively in LCA could result in positive outcome in other areas, such as lowering health risk through improving water hygiene and avoiding antimicrobial use. Based on these findings, we recommend stakeholders to focus on reducing impacts from the feed and give preference to the technologies highlighted in the above, duly taking into account local conditions.